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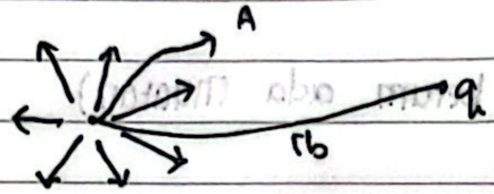
Pertemuan 10

usaha dan energi

-> usaha oleh muatan titik q



$W = \int - \vec{F}\, dt$

(-) : negatif karena melawan muatan sumber

$W = \int_A^B \vec{F}\, d\vec{s}$

$= -q \int \vec{E}\, dl$

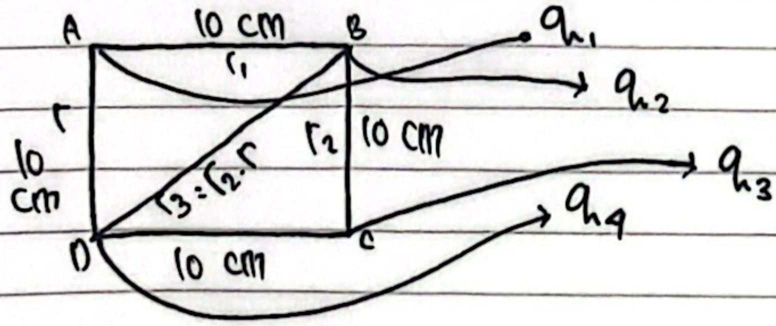
$= -q \left[\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}\, dt \right]$

$= -q \left[- \frac{q}{4\pi\varepsilon_0 r} \right]$

$-q$ → diganti dengan Q

$= Q\,[V]$

$= QV$



dik: q_1 pindah ke A = 0

q_2 pindah ke B

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q_3 Pindah ke C

q_4 Pindah ke D

muatan : $2\ \mu_c$

Panjang sisi : 10 cm

Jawab : $W_1 = q_1 V_1 = 0$ (karena belum ada muatan)

$W_2 = q_2 V_2$

$= q_2 \left[k \frac{q_1}{r} \right]$

$= q_2 V_c$

$W_3 = q_3 V_3$

$= q_3 \left[k \frac{q_1}{r_1} + k \frac{q_2}{r_2} \right]$

$W_4 = q_4 V_4$

$= q_4 \left[k \frac{q_1}{r_1} + k \frac{q_2}{r_2} + k \frac{q_3}{r_3} \right]$

$$W = \frac{1}{4\pi\varepsilon_0} \sum_{i=0}^{n} \sum_{j\neq 1}^{n} \frac{q_1 \, q_i}{r_{ij}}$$

- $W_1 = 0$
- $W_2 = q_2 \cdot V_2$

$= q_2 \left[k \frac{q_2}{r_{ab}} \right]$

$= 2 \left[4 \cdot \frac{2}{10} \right]$

$= 0{,}4$ dyne cm

- $W_3 = q_3 \cdot V_3$

$= q_3 \left[k \frac{q_1}{r_{ac}} + k \frac{q_2}{r_{bc}} \right] q_3 \rightarrow = 2 \left[1 \cdot \frac{2}{10} + 1 \cdot \frac{2}{10\sqrt{2}} \right] = 0{,}683$ dyne cm

- $W_4 = q_4 . V_4$

$$= q_4 \left[k\frac{q_1}{r_{ad}} + k\frac{q_2}{r_{bd}} + k\frac{q_3}{r_{ac}} \right]$$

$$= 2 \left[1 \cdot \frac{2}{10\sqrt{2}} + 1 \cdot \frac{2}{10} + 1 \cdot \frac{2}{10} \right]$$

$$= 1{,}08 \text{ dyne. cm}$$

$$\boxed{\begin{aligned} W &= \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{q_i q_j}{r_{ij}} \\ W &= \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{q_i q_j}{r_{ij}} \end{aligned} \Bigg\} \; W = \frac{1}{2} \sum_{i=1}^{n} q_i V}$$

- Energi dari muatan distribusi kontinu

Garis $\rightarrow \frac{1}{2} \int \lambda V \, dl$

Permukaan $\rightarrow \frac{1}{2} \int \sigma V \, dA$

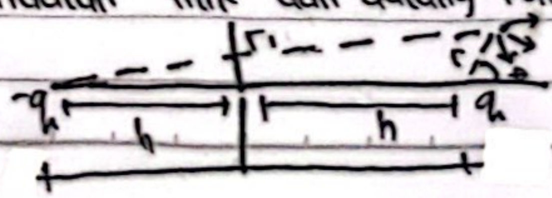
Volume $\rightarrow \frac{1}{2} \int \rho V \, d\tau$

$$W = \frac{\varepsilon_0}{2} \int_{\text{surface}} E^2 \, d\tau$$

$\boxed{\text{Bab 3. Metode Penentuan Potensial}}$

Metode bayangan

1. muatan titik dan datang konduktor



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$$P = \frac{1}{4\pi\varepsilon_0}\frac{q_h}{r}$$

$$= \frac{q_h}{4\pi\varepsilon_0 r'}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r} \cdot \frac{1}{r_1}\right]$$

$$r' = \sqrt{(2h)^2 + (r)^2}$$

$$= \sqrt{4h^2 + 4hr\cos\theta + r^2}$$

$$V_3 = V(r,\theta) = \frac{q_h}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{(r^2+4h^2+4hr\cos\theta)^{1/2}}\right]$$

Turunkan terhadap r

$$E_r = -\frac{\partial q}{\partial r} = \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r^2} - \frac{t+2h\cos\theta}{r'^3}\right]$$

Turunkan terhadap θ

$$E_\theta = -\frac{1}{r}\frac{\partial v}{\partial\theta} = \frac{q_h}{4\pi\varepsilon_0}\left[\frac{2h\sin\theta}{r'^3}\right]$$

Turunkan terhadap z

$$E_z = E_r \cancel{E_\theta} \cos\theta - E_\theta \sin\theta$$

$$= \frac{q_h}{4\pi\varepsilon_0}\left[\frac{\cos\theta}{r^2} - \frac{r\cos\theta + 2h}{(r^2+4h^2+4hr\cos\theta)^{5/2}}\right]$$

$$AB = r = r' = a$$

$$E_z = \frac{q_h}{4\pi\varepsilon_0}\left[\frac{\cos\theta}{r^2} - \frac{r\cos\theta+2h}{(a)^3}\right]$$

$$= \frac{-q_h}{4\pi\varepsilon_0}\left(\frac{2h}{a^3}\right)$$

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$$= \frac{-q_h}{2\pi\varepsilon_0}\left(\frac{h}{a^3}\right)$$

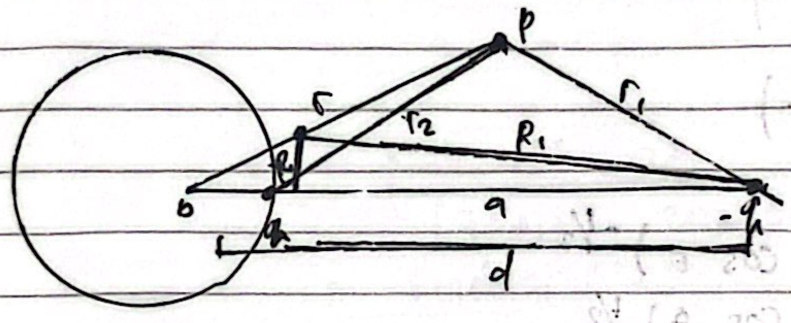
$$= \frac{1}{\varepsilon_0}\,\sigma_{(a)}$$

$$\iint \sigma \, dA = -hq_h \int_0^{\infty} \frac{x}{a^3}\, dx$$

$$= -hq_h \int^{\infty} (ada)$$

$= -q_h$ muatan bayangan

2. Muatan titik dengan bola konduktor



$V_0 = 0$

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_{h1}}{R_1} - \frac{q_{h2}}{R_2}\right) = 0$$

$$R_1^2 = a^2 + d^2 - 2ad\cos\theta$$

$$R_2^2 = a^2 + b^2 - 2ab\cos\theta$$

untuk $V_0 = 0$, maka

$$\frac{a_1}{R_1} = \frac{q_{h2}}{R_2} \rightarrow \frac{q_{h1}^2}{q_{h2}^2} = \frac{R_1^2}{R_2^2} = \frac{a^2 + d^2 - 2ad\cos\theta}{a^2 + b^2 - 2ab\cos\theta}$$

$$\left(\frac{q_{h1}}{q_{h2}}\right)^2 + \left(\frac{R_1}{R_2}\right)^2 = \frac{d}{b}\left(\frac{q_h^2\,/a + d - 2ad\cos\theta}{q_h^2\,/a + b - 2ab\cos\theta}\right)$$

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1. $q_h^2 : db$

2. $\left(\frac{q_{h1}}{q_{h2}}\right) : \frac{d}{b}$ karena $d > b$ dan $q_{h1} > q_{h2}$

$\frac{q_{h1}^2}{q_{h2}^2} : \frac{d}{b} : -q_{h2} : 1\sqrt{\frac{b}{d}} . q_{h1}$ untuk $b = \frac{q_h^2}{d}$

$q_{h2} : -\frac{q_h}{d} \times q_{h1}$

Jadi $V(r, \theta) : V_P$

$V_P : \frac{1}{4\pi\varepsilon_0}\left(\frac{q_{h1}}{r_1} - \frac{q_{h2}}{r_2}\right)$

$: \frac{1}{4\pi\varepsilon_0}\left(\frac{q_{h1}}{r_1} - \frac{q/d}{r_2}\right)$

$r_1 : (r^2 + d^2 - 2\,ard\,\cos\theta)^{-1/2}$

$r_2 : (r^2 + b^2 - 2ard\,\cos\theta)^{1/2}$

• $V_P : \frac{q_{h1}}{4\pi\varepsilon_0}\left(\frac{1}{(r^2+d^2-2rd\cos\theta)^{1/2}}\right) - \frac{q_h/d}{\left(r^2 + \frac{a^4}{d^2}\left(\frac{d^2}{d}\cos\theta\right)\right)^{1/2}}$

$E_r : -\frac{\partial V}{\partial r}$

$E_\theta : -\frac{1}{r}\frac{\partial V}{\partial \theta}$

4/ → Permukaan bola $r = a$

$E_r : -\frac{q_{h1}}{4\pi\varepsilon_0}\left[\frac{-(a - d\cos\theta)}{(a^2+d^2-2ad\cos\theta)^{1/2}} + \frac{\frac{q_h}{d}(a - q_h^2/d\cos\theta)}{\left(a^2 + \frac{a^4}{d^2} - 2\,a/\frac{q^2}{d}\cos\theta\right)^{3/2}}\right.$

$+ \frac{\frac{d^2}{d}(1 - a/d\cos\theta)}{a^5/d^3\,(a^2+q_h^2-2ad\cos\theta)^{3/2}} + \frac{d^2/a\,(1 - b^3/d\,\cos\theta)}{(q_h^2+d^2-2ad\,\cos\theta)^{3/2}}$

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$$E_r = \frac{q_1}{4\pi\varepsilon_0}\left[\frac{-(a-d\cos\theta)+\frac{d^2}{a}\left(1-\frac{a}{d}\cos\theta\right)}{(a^2+d^2-2ad\cos\theta)^{3/2}}\right]$$

$$E_r = \frac{q_1}{4\pi\varepsilon_0}\left(\frac{d^2-a^2}{(a^2+d^2-2ad\cos\theta)^{3/2}}\right)$$

dengan cara yang sama

$E_\theta = 0$

Disini terjadi Pergerakan listrik D

$D = \varepsilon_0 E \quad \rightarrow \quad = \sigma_F \cdot \sigma$

$\sigma = \varepsilon_0 E_r$

$$= \frac{-q_1}{4\pi a}\left(\frac{d^2-a^2}{(a^2+d^2-2ad\cos\theta)^{3/2}}\right)$$

σ : muatan (induksi / satuan luas pada bola konduktor)

F : gaya antara bola dengan q_1.

$$F = -\frac{1}{4\pi\varepsilon_0}\frac{q_1 \cdot q_2}{(d-b)^2}$$

$$= \frac{-1}{4\pi\varepsilon_0}\frac{q_1 \cdot q_1^2}{{}^2/(a-d)^2}$$